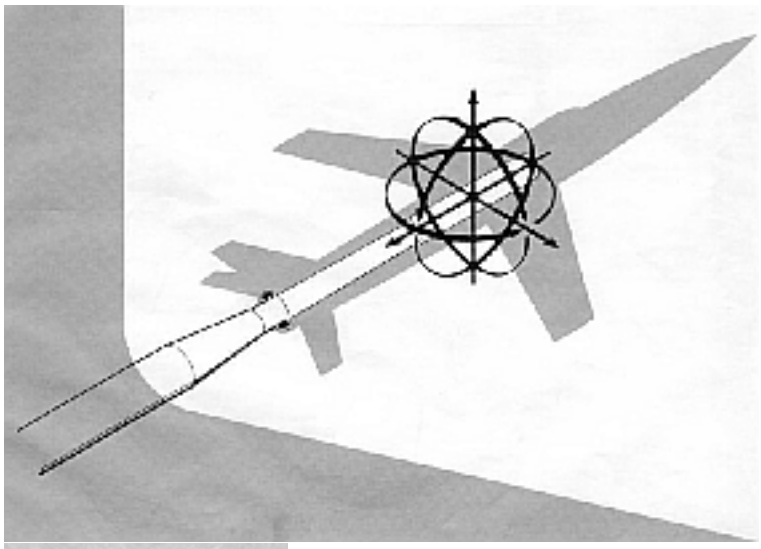
Able Corporation Series D Six Component Internal Strain Gage Balance



ABLE CORPORATION

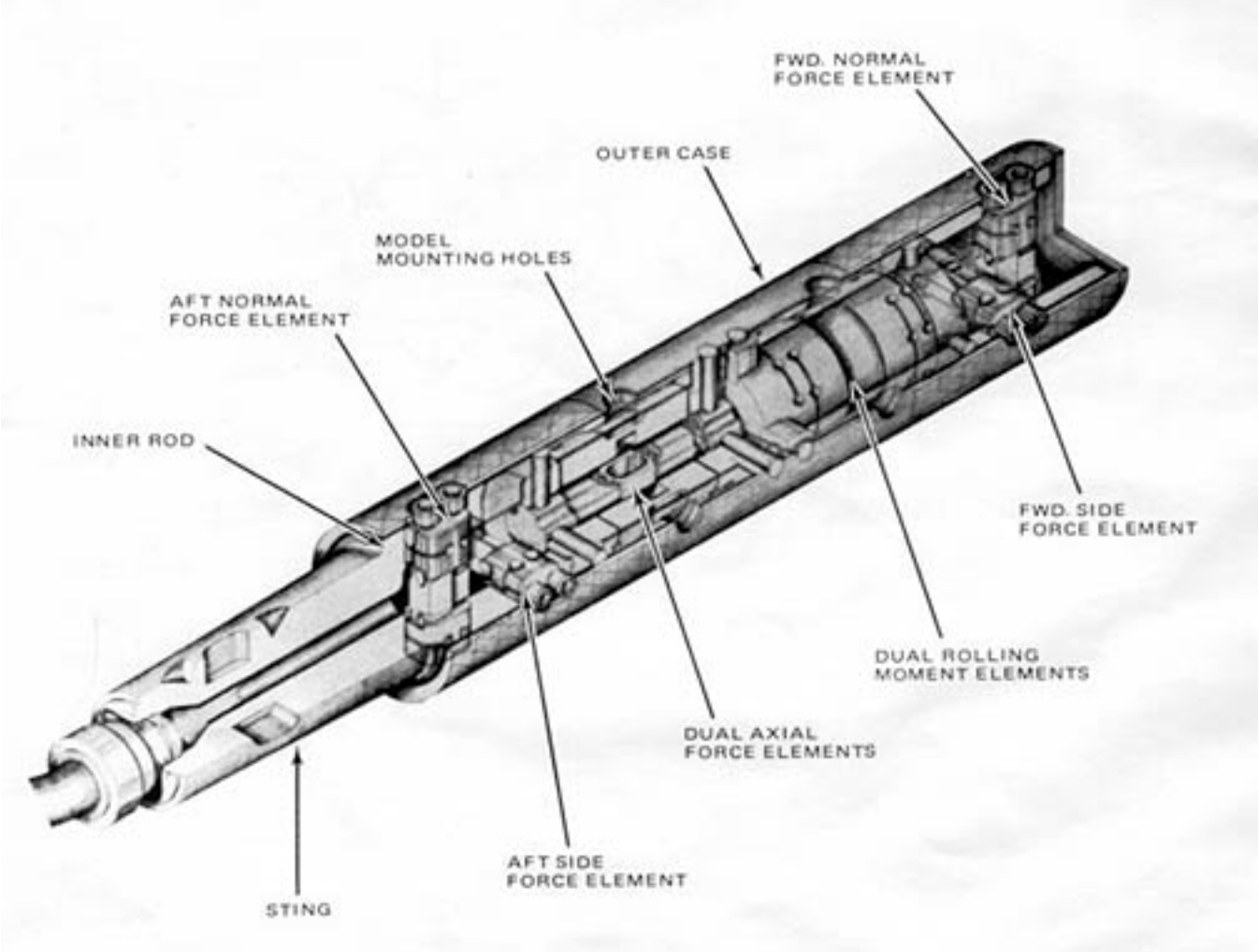
[Copied from a 1960s Able Corporation brochure. Task Corp. name was changed to Able.]

General Description

The Able Corporation Series D, six-component internal strain gage balance is basically a floating-frame type. The primary frames consist of an inner rod, which fastens to the model support sting, and a cylindrical outer case, which is inserted into and attaches to the model. Forces and moments are resisted by individually removable elements, employing flexure pivots, connected between the inner rod and outer case of the balance.

The six force and moment sensing components of the balance consist of two normal force elements for determination of normal force and pitching moment, two side force elements for determination if side force and yawing moment, a dual axial force element and a dual roll moment.

The normal and side force elements are equipped with relaxation members at either end and are arranged to act in roll as a set of crossed flexures. Similar relaxation members provide compliance in the axial force direction. The rolling moment elements are provided with flexure pivots at either end, which are designed to transmit pure rolling moment to the gage section. The dual axial element is located inside the dual roll element and transmits axial force from the outer case to the inner rod.



Performance

Accuracy
All points from any series of loadings of a single element produce data within ±0.25% of maximum load or ±0.5% of applied load when compared with the best straight line fit. This accuracy is inclusive of all scatter, hysteresis, and non-linearity for both plus and minus loads.

Interactions
Percentage interactions on any gage member caused by the application of full design load on any other gage member fall within the following values: Seventy percent of the possible first order interactions will be less than or equal to 0.5%. An additional 20% of the first order interactions will be less than or equal to 1.0%. The remaining 10% of the first order interactions will be less than or equal to 3.0%. All interactions in excess of 1.0% will be linear within ±10% of the interaction output.

The percentage values of the first order interactions may change slightly if specifications require a small diameter balance or a very light or very heavy load range.

Thermal effects [not used in years]
Transient temperature errors in any gage element do not exceed 1.0% of full load output when the sting temperature is constant or changing and the outer case temperature is changing at a rate of 50° F per minute between 60° F and 180° F.

At stabilized temperatures, the error in any gage element does not exceed 0.5% of full load output between 60° F and 180° F.

Sensitivity
Full load output of any gage member is approximately 1 millivolt per volt input.

Gage characteristics
Bridge resistance is 350 ohms for normal and side force elements.

The basic bridge resistance of the rolling moment and axial force elements is 350 ohms. However, these components each operate with two full bridges wired in parallel. Thus the resistance is 175 ohms.

Operating voltage of each element is 6 to 12 volts. Lower voltage is recommended for balances 0.75-inch diameter or less.

Performance Evaluation

Each balance is subjected to a performance evaluation to demonstrate satisfactory operation of all functions. It is expected that a more detailed calibration, tailored to the individual laboratory's needs, will be performed by the user. More complete calibrations can be performed by Able if desired.

Temperature Compensation Principle

The arrangement of axial force elements provides complete mechanical compensation for radial temperature gradients. The two axial force element strain gage bridges are wired to produce a signal when the forces on the two elements are opposite in sign. (This occurs only when an external axial

load is applied.) If there is a length increment due to change in temperature added all along the inner rod or outer case, each axial force gage will experience an increment of load having the same sign and the signals will cancel. Thus the sensitivity of axial force to temperature gradients has been significantly reduced.

Strain Gages

All gaged sections, with the exception of rolling moment, are of the bending type employing 4-active foil type, epoxy bonded, 350-ohm strain gages. Rolling moment is resisted by a torque tube to which are bonded similar gages also wired in the form of a 4-active element bridge.

All strain gages are pre-matched in complete bridges for resistance and change in resistance with temperature. Bonding is accomplished using a combination of heat cycling and pneumatically applied pressure. After bonding, the individual bridges are again checked for temperature effects and trimming resistors are added where necessary.

Accessories

Able Corporation also produces all necessary balance accessories including:

- **Ring and plug gages** - Master gages for balance-to-sting joint
- **Balance gage** - Exact duplicate of the balance exterior and sting fitting. Center hole permits passage of leads when used in place of a balance.
- **Calibration body** - Loading sleeve used to apply loads for sensitivity and interaction calibration. Includes roll arm, precision circular level and flexures to which weight hangers attach.
- **Calibration rig** - Complete single or multiplane rigs for the application of calibrating loads outside of the tunnel.
- **Calibration weights** - Traceable to National Bureau of Standards are offered in the ranges 2#, 5#, 10#, 25#, 50#, 75# and 100#. Weight tolerance is ±0.1% of the total unit weight. More exacting tolerances are quoted on request.
- **Coolant jackets** - Required for balance operation up to stagnation temperatures of 1,500° F. Available for all balance sizes and require a minimal diameter increase.
- **Overload stops** - Available for roll and axial force in all balance sizes.

Standard Performance Calibration Procedure

1. Positive and negative design loads are applied to the balance outer case such that each force and moment element is loaded individually. The load on each element is applied in increments not greater than one-fifth of full design load.

Normal forces and side forces are applied orthogonally to the outer case, and axial force is applied along the axis of the outer case. Rolling moment is applied to the outer case by means of a moment acting in a plane normal to the balance axis.

Each gage output is tabulated and sensitivity calculated for each element in terms of millivolts per volt per pound or millivolts per volt per inch pound for both increasing and decreasing loadings. Interactions are plotted in terms of percent full load output in the member being interacted upon, versus applied load.

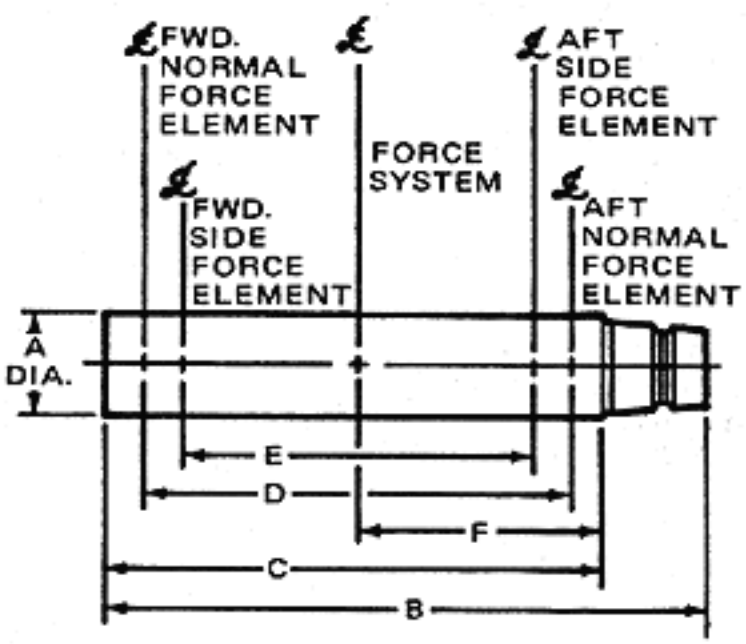
2. With the sting taper maintained at approximately 60° F the balance case temperature is increased at a rate of a least 5° F per minute until the balance has reached 180° F. The outer case temperature is then maintained at 180° F until the inner case temperature is stabilized, then the temperature is reduced at least 5° F per minute until the balance is again stabilized at 60° F. the output of all gages and thermocouples are recorded every two minutes throughout the run.

A similar test is also performed wherein both the sting taper and balance sleeves are raised simultaneously in temperature to 180° F.

With the balance at approximately 180° F, each component is loaded separately and the sensitivity in millivolts per volt per pound or millivolts per volt per inch pound is calculated.

Prior to assembly, the individual balance elements are subjected to a sudden pressure change from 2 to 60 psia and the outputs recorded.

Size And Ranges



Representative standard sizes and ranges of Series D balances are given in the table. The force and moment values shown are based on typical requirements. Other sizes and/or load ranges are available either as new designs or modifications of existing types. There are over 200 standard designs currently available.

DIMENSION	0.5" MK IV	0.75" MK XLI	1" MK XIII	1.25" MK XIV	1.5" MK VI	2" MK XXVII	2.5" MK XVII	4" MK V
A, inches	0.5	0.75	1	1.26	1.5	2	2.5	4
B, inches	3.34	4.66	6.5	8.25	9.87	11.5	14.43	23.36
C, inches	2.74	3.83	5.1	6.28	7.23	8.9	11.16	16.75
D, inches	2.1	3	4.3	5.25	6	7.25	9	14
E, inches	1.7	2.5	3.5	4.25	5	6	7.5	11.5
F, inches	1.28	1.8	2.5	3.03	3.6	4.38	5.28	8.06
N1, pounds	75	100	250	650	1000	1500	2500	6000
N2, pounds	75	100	250	650	1000	1500	2500	6000
S1, pounds	40	50	150	325	500	800	1250	3000
S2, pounds	40	50	150	325	500	800	1250	3000
A, pounds	50	30	75	90	150	200	300	500
ROLL, inch-pounds	20	100	150	600	1,200	2,000	4,000	12,000
PITCH, inch-pounds	158	300	1,075	3,413	6,000	10,875	22,500	84,000
YAW, inch-pounds	68	125	525	1,381	2,500	4,800	9,375	34,500